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The follow-up ripple effects of Railway on Regional economy---Lillestrøm case study

MSc in Innovation and Entrepreneurship

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ACKNOWLEDGEMENTS

First and foremost I offer my sincerest gratitude to my supervisor, Dr Tor Borgar Hansen, who has supported me throughout my thesis with his patience and knowledge whilst allowing me the room to work on my own way. I attribute the level of my Master's degree to his encouragement and effort. One simply could not wish for a better or friendlier supervisor.

During the two years study, University of Oslo stimulated me with creative ideas and thinking. I had a dream to be an entrepreneur, and I think I have completed the relevant stock of knowledge from this major. I realized that the technology innovation is the origin of society's economy. By totally realizing technological innovation grows society's economy, I wish to make a contribution to the commercialization of new technologies after graduation.

Many thanks to Grunderskolen for giving me the chance to take part in the exchange program at Rice University in Houston, Texas. It was really an exciting experience in my life. I finally understood the American dream there, and I wish to implement the dream in Norway.

In the end, my gratitude also goes to TØI, I got mindful help from Kjell Werner Johansen, Knut Sandberg Eriksen and Yu Bai, and they guide me to the right direction and avoid the detours.

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1. INTRODUCTION

Since the first railway line between Christiania and Eidsvold was put into use in 1854, Norway's economic development has been accompanied by the development of the railway. What is the relation between railway and economy? Is it positive or negative? What is the effect of railway on one specific region's economy?

With these three questions, a meeting at The Institute of Transport Economics (Transportøkonomisk institutt stiftelsen Norsk senter for samferdselsforskning), TØI, was held. The meeting was with Kjell Werner Johansen (Vice president), Knut Sandberg Eriksen (Forsker II) and Yu Bai (Forsker), the three of whom introduced the current situation of the transportation economics' research in Norway. Emphasis was placed on the lack of research and literature in this field. TØI has done much research on roads, not on railway. The TØI researchers acknowledged there are a few works on freight trains, which they provided. In the end, the TØI researchers maintained that the field is interesting, and obliged to aid during the research.

This article answers these questions. First, the literature review presents the results of previous research. Railway infrastructure investment has two effects on the economy: Forward-induced effect of railway construction on economic growth and railway construction follow-up ripple effects on economic growth. Second, the "before-after comparison" method is used to analyze the economic change of Lillestrøm due to the construction of Gardermoenbanen. It shows Gardermoenbanen made a positive effect on the regional economy by several aspects: economic growth rate, new established company quality and commuter facility. Third, the conclusion is drawn: railway investment would make a positive effect on regional development and economic growth.

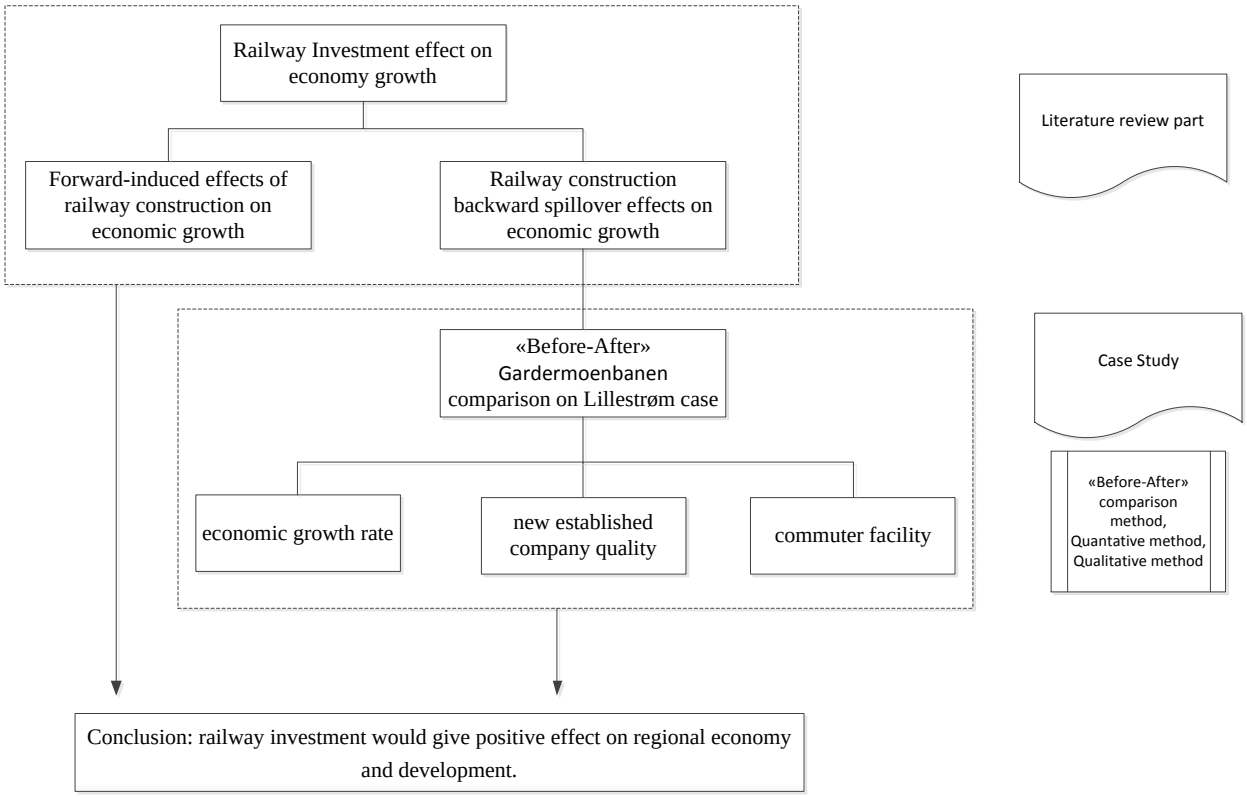


Figure 1.1 Research Process

1.1 Research problem and questions

The relation between the economy and railway is not clear. The outcome is an obstacle to planning regional economic development, railway investment, national transportation plans. As important infrastructure, the contribution of railways to society needs to be known. Is a new railway line positive to the economic growth rate in this region? Is a new railway line positive to the quality of new established companies in the region? This research will solve these societal and economic puzzles.

2. LITERATURE REVIEW

2.1 Literature on the impact of railway infrastructure on economy

(1) Early studies of the promotional role of transportation on the economy

The rise of rail transport occurred in the 1930s, which became the new overlord of the modes of transportation with advantages on the occasion of its birth. Before the birth of railway, the famous British economist, Adam Smith (1776) had realized the importance of transport to the economy. In his masterpiece "The Wealth of Nations", it is discussed the role of transport in promoting economic development from multiple angles.

(2) The impact of rail on economic growth and modernization

After the birth of the world's first railway in 1825, with more than a century's development, rail transport is found all over the world and made a great contribution to the economies of many countries. American economist Trelease, Allen W. (1991), in his book "The North Carolina Railroad, 1849-1871", and the modernization of North Carolina through the analysis of that period, assessed the role of the railway, the economic growth of North Carolina, USA and the impact to modern society by analyzing the development and role of rail in different historical periods.

Spanish economist Herranz-Loncan, Alfonso (2006), in his paper "Railroad Impact, in of Backward Economies: Spain, 1850-1913 " has re-evaluated the contribution of railways to Spain's GDP during 1850 -1913 with a comparison to British Rail's contribution to GDP. (Atack, Jeremy; Bateman, Fred, U.S. civil servant, and Haines, Michael; Margo Robert A (2009) report on its work "Did Railroads Induce or Follow Economic Growth?) Urbanization and Population Growth, in the American Midwest.1850-60", proposed railway is able to promote economic growth through the analysis of the U.S. Midwest population density and population growth. In the 1850s, the railway is the main reason for urbanization of American Midwest. The population doubled due to the arrival of the railway.

2.2 Literature about the impact of regional train on regional economies

The impact of high-speed rail to regional social and economic development has been the focus of attention of scholars and researchers. There are some studies based on different perspective and approach.

In theoretical studies, U. Blum, K, et al. (1997) concluded that High-speed rail connecting cities

and regions improve the accessibility of cities inside the regions. An important hypothesis of the study is that cities connected by high-speed rail are an expansion of the functional areas and form economic corridor to a certain extent. Blum analyzed the economic integrity of the economic zone from the short, medium and long term. Kiyoshi Kobayashi (1997) proposed a system model composed of a number of cities connected by a high-speed rail system. The result is that high-speed rail systems can increase the production department of the cities. Fernand Martin (2000) pointed that the construction of high-speed railway has a positive effect to improve the economic zones by the transportation capacity and the rational configuration of the transport market. E. Kingsley, in The Hayne (1997) discussed employment issues, pointing out that the regional railway would is beneficial to the area.

In empirical studies, some experts analyzed the impact of the social economy from different angles based on the railway line inside one economic region. David Ellis (2010) took Tennessee Railway as an example, to build the construction of high travel demand model to forecast the regional railway time-effective, accessible-effective, and recognized regional railway will promote the economic development of Tennessee. Sasaki (1997) measured the impact of the Japanese Shinkansen system from a regional socio-economic perspective. Sasaki showed there is a positive correlation between the Shinkansen system and economic development. The relationship was shown to be a linear correlation between GDP and passenger in Japanese Tokaido, Sanyo Shinkansen. Nakamura and Ueda used a placeholder holder variable to, "yes" and "no", to analyze the situation of industry employment in the case of Shinkansen. Significant employment growth occurred in the third industry, especially in tourism and services sector. Gutierrez, J. Gomez, G (1996) studied the potential impact of the European high-speed railway accessibility; the results validated high-speed rail can improve accessibility of the nodes in the region between the cities. Gerard Mathieu, (1993) evaluated the impact of French regional rail on economic development. The surrounding area of Lyon has become the fastest growing region after the rail station was built. The office space near the station increased from 175,000 m^2 to 251 000 m^2, with an average annual growth rate of 5.20% from 1983 to 1990. Lyon is a traditional Industrial city, after the opening of the high-speed railway, the industrial structure of the whole city was influenced. The third industry has been rapid growing.

2.3 Railway investment affects regional economic development

Railway investment here mainly refers to the railway infrastructure investment. The construction and operation of rail infrastructure has an important impact on regional economic development.

Many economists have been engaged in this field, and have pointed out that there are two types of effects of transport infrastructure on regional economic development: Forward-induced effects of railway construction on economic growth and Railway construction follow-up ripple effects on economic growth

2.3.1 Forward-induced effects of railway construction on economic growth

First, the effect of economic activity affecting economic output—forward-induced effects—is seen in building transport infrastructure to boosts economic development. Rail construction projects affect regional economic development. Transport infrastructure must produce demand of factors of production, thereby increasing the investment of factor markets, and prosperity factor market will stimulate the consumer market investment, so construction of transport infrastructure will stimulate much investment.

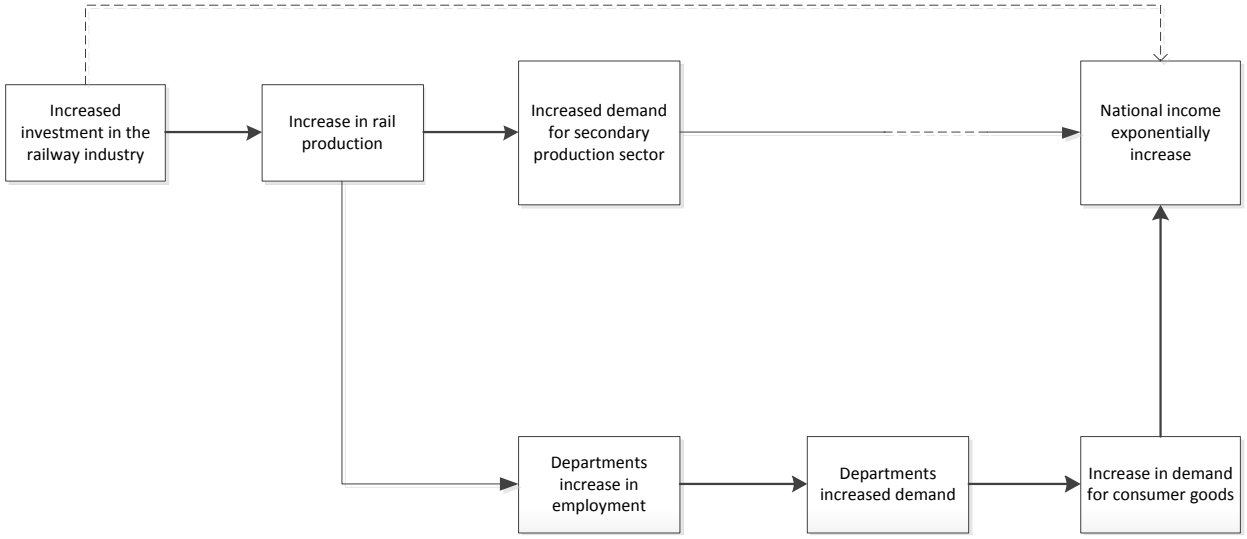


Figure 2.3.1 Forward-induced effects of railway construction on economic growth

2.3.2 Railway construction follow-up ripple effects on economic growth

Second, railway construction has follow-up ripple effects on economic growth—direct and indirect contribution of transport infrastructure built on regional economic development once in operation. The direct contributions include lowering transportation costs, saving shipping time, reducing overcrowding, improving accessibility and safety. New infrastructure put into operation is able to alleviate the transport pressure to reduce the crowded lines, transportation time and transportation costs. New transport modes make the existing transportation network more dense and smooth, thereby increasing the accessibility and safety.

The indirect contributions of operational railway infrastructure are improved investment environments, optimized industrial structure, accelerated urbanization process and formation of economic traffic belt.

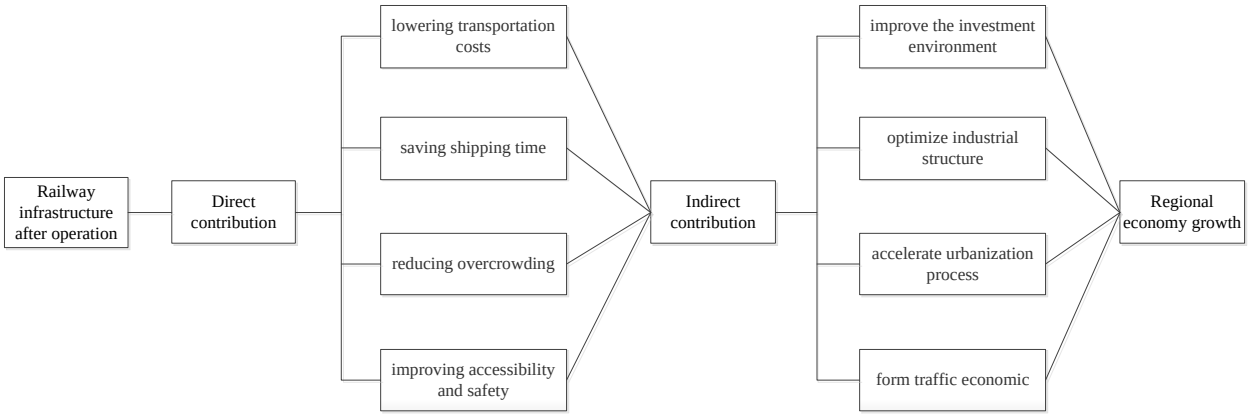


Figure 2.3.2 Railway construction follow-up ripple effects on economic growth

2.3.2.1 Promote the increase of overall economic growth of the region

The role of transportation to promote the total regional economic growth is mainly reflected in two aspects. The first is the investment multiplier effect and associated industry effect. Transport infrastructure investment would produce new elements of demand, pulling related industrial development to promote the total regional economic growth. The second is the direct economic effect. After the infrastructure is built and put into operation, it could alleviate the pressure of transport, reduce congestion, save transport time, reduce transportation costs and increase transportation income. Aschauer (1989), Biehl (1986) and Blum (1982) pointed out the level of infrastructure could help explain the productivity growth rate difference between countries. Aschauer (1990) made a comparison between Japan and the United States. Transport infrastructure investment in Japan accounts for 5.1% of the total investment in the facilities of public investment, resulting in 3.1% productivity growth per year; while in the United States, only 0.3% of public facilities investment is used in transport infrastructure with an average annual 0.6% productivity growth. Emmanuel (1995) indicated the crop yielded 0.26% more due to the increase in the density of paved roads and rural road network in some developing countries.

2.3.2.2 Optimize the structure of regional industrial

Regional industrial structure is the ratio between the regional primary industry, secondary industry and tertiary industry. Optimization of industrial structure is to achieve a rational allocation of the proportional relationship between the different industries, and to seek the industry to upgrade. Developed transportation systems may eliminate the geographical limits between the different regions to accelerate the formation of Common Market in the region. The principle of survival of the fittest competition in the market economy can change the mode of economic growth, optimizing the structural relationship of different industries. As a result, the

regional economy would develop to the direction of integration. The higher the degree of the economic integration is, the larger the scale of the industry will be formed, which would further enhance the transport routes to cover an area to promote the development of tertiary industry and high-tech industries.

2.3.2.3 Change the distribution of productive forces

Improvement of transportation conditions closely connects the production with consumption, eliminating the contradiction between supply and demand. The place to produce could be farther away from the place to consume. The agricultural production base is generally located in the suburbs; more processing plants are gathered in marginal urban areas. If there is no convenient and efficient transportation network to support, the raw materials and products would not be able to delivery to the destination timely. As a result, the production base of agricultural products and processing plants could not spread to the outskirts of the city.

2.3.2.4 Strengthen regional economic ties

An important prerequisite for regional economic development is the rapid movement of personnel and resources. If the process flow of personnel and resources is restricted, the production, consumption, exchange and distribution of all parts will have been varying affected. Transportation is the basic condition of movement of people and goods, and can promote two-way flow of inter-regional resources, achieve the optimal allocation of resources in the market competition mechanism, break regional restrictions of economic development, access to resources in the broader social environment and gain a larger market space for development. At the same time, well-developed transportation networks are also a good opportunity for industrial scale and upgrading industrial structure.

2.3.2.5 Accelerating the urbanization process

Urbanization is the process of socio-economic changes. It includes the scale of the urban population expanding, urban land extending to the suburbs, the number of cities increasing and urban social, economic, technological changes entering the villages in the process. From the definition of urbanization, the process requires a large number of staff and capital flows. The agricultural population converting to non-agricultural population means the agricultural population flows to the cities, while urban land extending to the suburbs shows that the capital injection in suburbs is needed to exploit available land. These processes are inseparable from

transportation systems. Without advanced transport networks backing up, the resources between towns and cities centers could not be a rational flow, and resources could not be fully utilized, so the process of urbanization would be severely affected.

2.4 Mechanical formation of economic region based on traffic

As early as the beginning of 20th century, some scholars have noted that transport along the formation of certain region promoted the economy of the region, and tried to demonstrate it theoretically. Alfred Weber and Gorz came up with classic industrial location theory about economy of scale, the regional economy of scale and urban economy of scale. In 1927, an American scholar Stan and a German, Jill, continued to strengthen the linkages between the industrial centers in the early industrial quadrilateral "concept based on the proposed concept of" manufacturing and the Manufacturing Belt.

2.4.1 Growth pole and growth center theory

In the 1950s, French economist, F. Peoux proposed a growth pole theory with the joint efforts of the French economist JR Boudeville. The concept of the growth pole is extended to the significance of the geospatial city, town or other geographic units such as the first propulsion unit, and underdeveloped areas. The basic content of the growth pole theory are:

(1) The development of one or several of the leading industrial sectors with economic and technological links with other economic production will be driven by the corresponding development of other sectors. That means the development will be often affected by other sectors compared with its own development.

(2) The results of the above development for the region are production greater than their own needs.

(3) The growth pole extends to all directions in the surrounding area: The "polarization", which is gathering process, is an increase of its very strong economic and technological strength and favorable conditions.

(4) Diffusion tends to be the dominant process of the growth pole theory. On the one hand, the proliferation of material and energy output and space develops itself, so it grows pole scale, increasing strength; On the other hand, the formation of the new growth pole will promote the progress of diffusion.

2.4.2 Growth axis theory

Growth axis theory is a direct combination of transport and regional economic development. Werner Sombart, in the 1960's, stressed that the construction of transportation routes will guide and promote the role of economic activity. The theory is that connecting the center of the city's major transportation routes (rail, road) will form a new and favorable location, convenient movement of population, and reduce transportation costs, thereby reducing the cost of production. The new traffic arteries of industrial zones will attract labor, form the favorable investment environment, and gather the corresponding industry, resulting in new industrial zones and residential areas. An axis of transportation as a "spindle" will gradually form an industrial zone, and transportation routes act as the foundation of the formation of the axis of development. Territorial control plans in the Federal Republic of Germany, according to the growth axis theory, improved traffic conditions, adjusting the size of investment and population in one region to guide the construction of industrial zone. In the end, it achieved good results.

2.4.3 Theory of point-axis system

In 1984, Lu Dadao, a fellow of the Institute of Geography in The Chinese Academy of Sciences, proposed a theoretical point-axis system. The theory is developed by growth pole theory and the growth axis theory. In the point-axis system, "points" are the town centers, which are the gathering point of regions at all levels, which also leads the development of regions. The "axis" is relatively intensive industrial or residential regions formed by a number of different levels of center cities and towns in a certain direction. The axis and the surrounding areas have a strong economic strength and potential development, so it is called "development axis" or "exploit axis". And this development axis generally refers to the belt region along linear infrastructure (transport links, energy transmission lines, water lines and communications lines). The axis is actually a linear zone (Belt).

The point of an axis system theory holds that the development axis consist of three parts: (1) transportation routes; (2) the main parts of the development are urban, industrial and mining areas, ports, suburbs, agricultural, and other mechanized agricultural facilities which lies in linear infrastructure beam or the intersection of the main beams; (3) the area could be attracted by development axis. Organization of the development model in productivity, geographically, is a 'point - axis and gradual diffusion'. In the theory, first select the main axis with good conditions of linear infrastructure beam along the traffic, then, develop the main city or town with high priority for the surrounding axis areas and along the zone. Cities will affect the surrounding area

to drive the growth of the economy, and the main axis will expand itself to several second level axes, thereby stimulating the development of the region as a whole.

2.4.4 Mega-cities theory

Jean Gottmann and members from the Princeton Institute for Advanced Study, in 1942, went to the Eastern seaboard of the United States to investigate. Gottmann noted that large cities with small surrounding towns developed very fast along the Appalachian foothills; such as Boston, New York, Philadelphia and Washington. In 1957, Gottmann returned to inspect the region, and was keenly aware of a new situation stretching from Hillsborough, New Hampshire to Fairfax Virginia along the main city traffic. Gottmann observed that urbanization along this corridor was forming a major axis 600 miles long with a population of more than 30 million in a rolling urban zone. Essentially, the major cities were agglomerating with the surrounding towns. The term Gottmann coined for this new spatial geographic unit is derived from the legend on the Peloponnesian plateau of ancient Greece, Megalopolis—meaning both mega-city and intensive industrial belt. This zone is known as the Boston-Washington corridor.

3. Methodology

Most of Norway's rail network was established over 150 years ago, and only Gardermoenbanen was opened in 1998 through Lillestrøm. This thesis selects Lillestrøm as a case study to research the railway construction follow-up ripple effects on economic growth in this region. The 'Before-After' method is used in this case study. It compares several economic factors before the year 1998 and after the year 1998 to indicate the effect of railway construction on Lillestrøm's economic development. First, an analysis of the in- and out-flows of commuters in Lillestrøm indicates Gardermoenbanen plays an important role for employees around Lillestrøm. Second, an analysis of Lillestrøm's GDP before and after Gardermoenbanen shows the increased economic growth may be attributed to the new railway line. Third, the number of new established companies and educational attainment of employees are analyzed; indicating Lillestrøm has established a good environment to attract new companies and more highly educated workers. Fourth, the quality of newly established companies is analyzed and indicates Lillestrøm provides a fertile environment for sustained cultivation of attracting new companies.

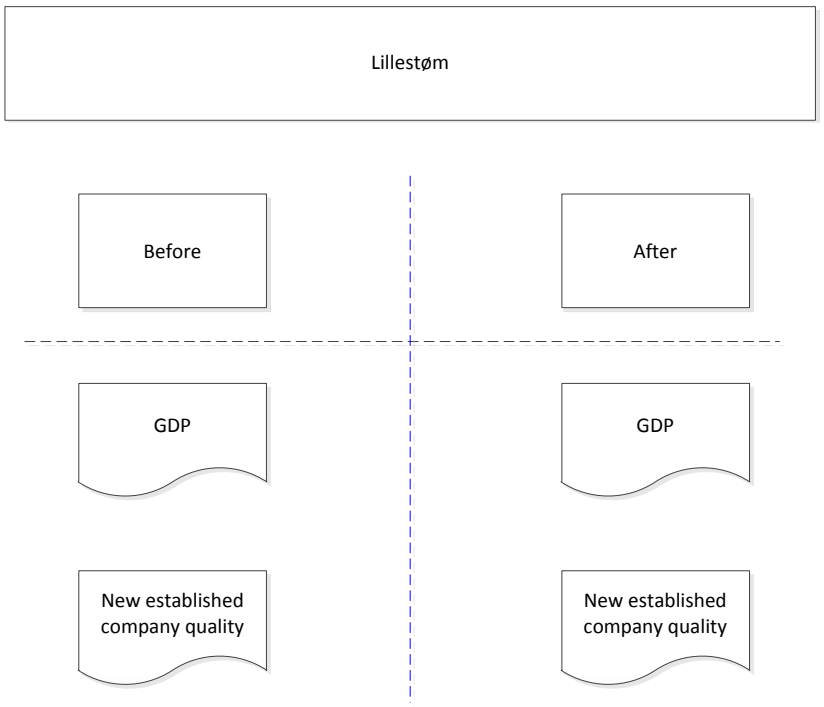


Figure 3.1 Before-After comparison method

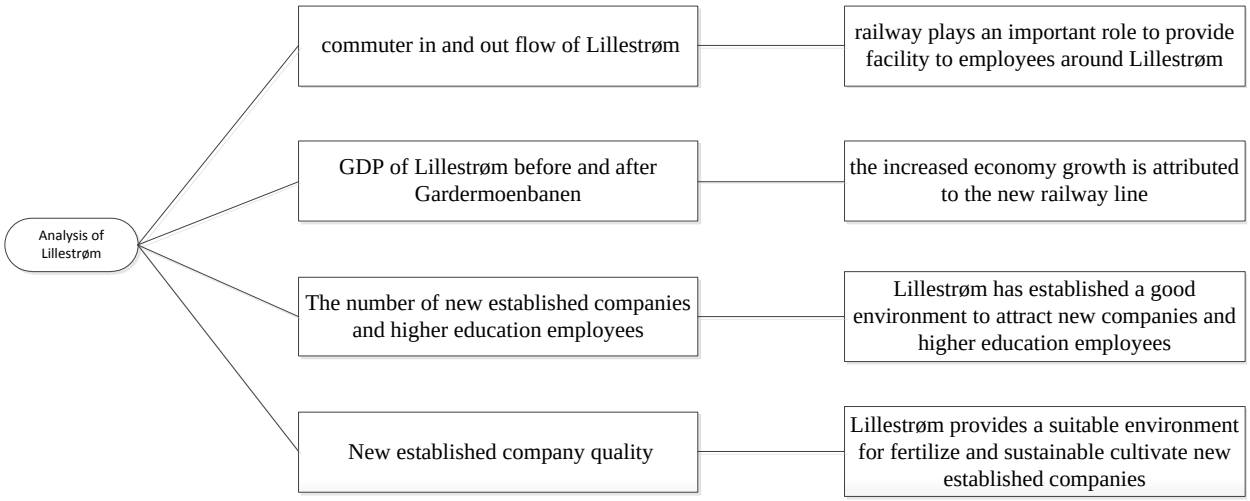


Figure 3.2 Case Study process

Quantitative method is used in “Before-After” comparison process. First, the Chow breakpoint test is used to validate the year 1998 is the break point of the GDP year series 1990 to 2011. Second, the series 1990 to 2011 is divided into two series by breakpoint (1998): 1990 to 1998 and 1999 to 2011. Third, the average economic growth rate is calculated of the two new series, which shows the second is definitely higher than the first. Fourth, the regression equation is deducted by least square method. By comparing the two equations of the two series, it finds that the slope of the second is larger than the first, which indicates that the 1999 to 2011 series is significantly improved.

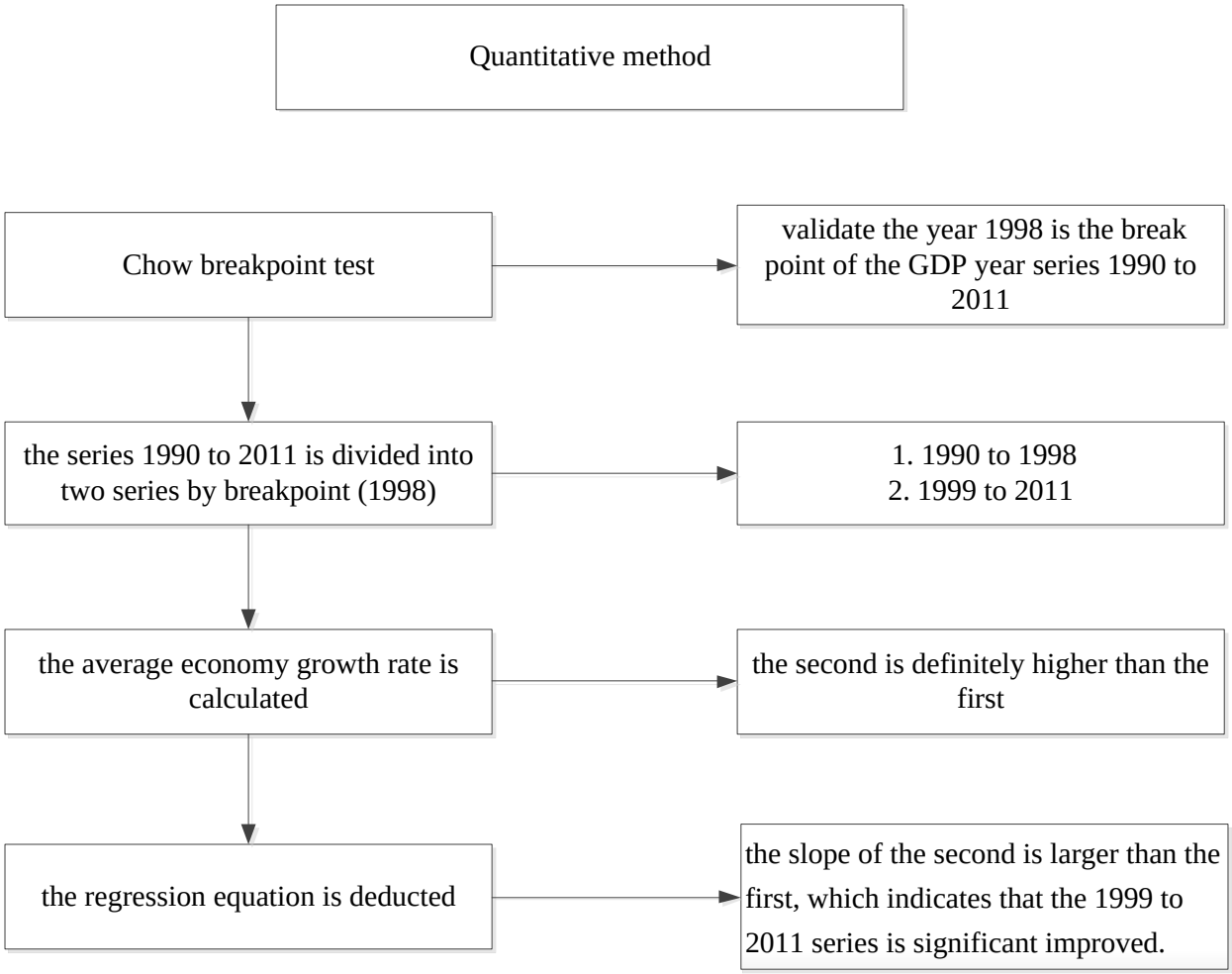


Figure 3.3 Quantitative method

3.1 Validity

During the research, helpful instruction was provided by TØI, Tor Borgar Hansen. TØI introduced the current research situation and issued the challenge of the research. Tor Borgar Hansen, thesis supervisor, gave close guidance to the research. Both the team at TØI, described in the Introduction, and Professor Hansen provide directional support of the research, which is the function of validity.

4. LILLESTRØM CASE STUDY

4.1 Why choose Lillestrøm?

Appendix A lists the opening year for each Norwegian railway line. Most railway lines were opened over 150 years ago. Only Gardermoenbanen (64 km) and Askerbanen (9.7 km) were opened in the last two decades. Askerbanen was a four-track extending project that expanded a double track to a four track line. The Askerbanen project did not decrease the travel time nor increase the train frequency. In fact, the project did not improve the capability of the regional passenger flow. Gardermoenbanen, however, is the newly built rail line through Romeriksporten tunnel to connect Oslo Central Station (Oslo S) and Gardermoen Airport. Lillestrøm lies between them, which became the collective public transport center between Oslo and its primary airport. Lillestrøm enjoys a geographic advantage to develop town's economy and society. The commute to both Oslo S and Gardermoen Airport (airport), from Lillestrøm, was reduced to 10 minutes. Lillestrøm is the best city to do research on the following ripple effects of Gardermoenbanen's opening in 1998.

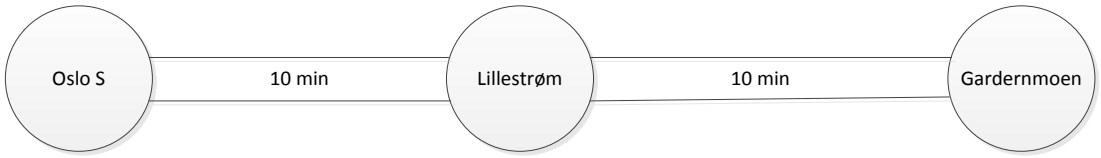


Figure 4.1 Geographic overview of Lillestrøm

4.2 NSB commuter train in Oslo Area (Local train)

NSB was a company with near monopoly on rail operations for a long time. Today maintained railway network of the National Rail (Jernbaneverket) (separated from the NSB in 1996) and many different train companies operate slots. The railway network in Norway consists of 4077 km of standard gauge track (1435 mm), of which 2518km are electrified and 214 km are double track. There are 702 tunnels and 2804 bridges.

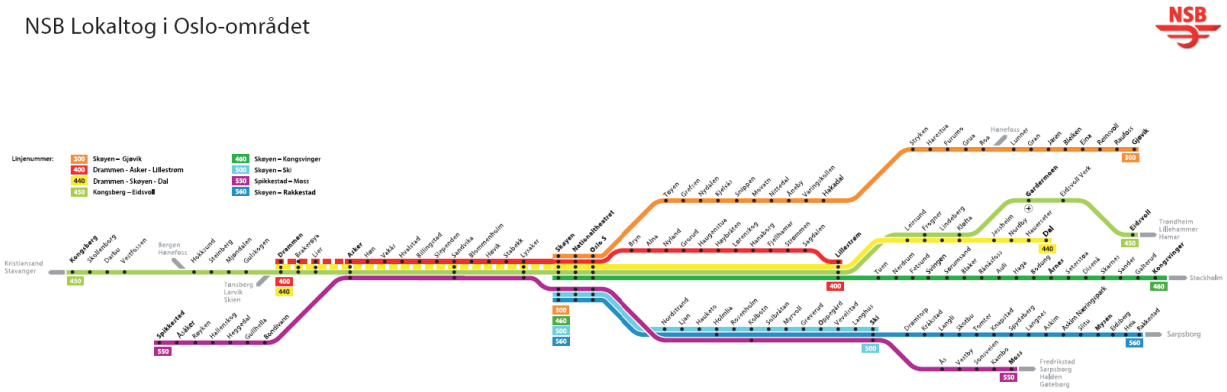
Commuter train (Local train) is the title of the local train service from NSB in Norway, primarily around the major cities. It generally uses the same infrastructure that was built for the regional and long distance trains, and sometimes their own stops or stations. Many stations and stops (e.g. Most between Oslo S and Moss / Mysen and between Oslo S and Årnes) are operated only by local trains, and on certain routes (e.g. Ski Mysen Asker Spikkestad) it runs only local trains. After completion of the Gardermoen line, the line between Oslo S and Lillestrøm has four tracks,

including the local train to Lillestrøm using the old tracks (Main Line), and permitting Local trains to use the new double tracks to Årnes through Romeriksporten.

NSB runs local trains in Stor-Oslo/Østlandet, Jæren in Bergen County, Trøndelag, Salten and the Grenland area. Local trains are the most prevalent in the Oslo area, there have been eight local train routes.

83.7 percent of all rail journeys were by local train, and almost 90 percent of these were in the Oslo area. Average rail trip was 30 kilometers which was clearly the shortest distance type. One billion four-hundred million passenger-kilometers accounted for almost half of the total transport work with the passenger.

4.2.1 Greater Oslo Area (Stor-Oslo områder)



Map.1 Routes of Commuter train in Oslo area

In the Greater Oslo area, the local train (commuter train) connects commercial centers Oslo S, Nationaltheatret, Skøyen, Lysaker, Sandvika, Asker, Lillestrøm, Kolbotn and Ski. The economic structure can be seen as a point-axis system. Each district center can be seen as a "point" and the commuter trains considered the `axes` to connect each center. The railway plays an important role in the local economy. Every day, the commuter train transfers thousands of employees inside this area, bringing commercial centers closer. Interaction theory could be applied to analyze this area. The railway transport optimizes the allocation of resources, which could promote the local economy. Conversely, with the development of a commodity economy, economic development has become more dependent on the transport. Economic growth requires the expansion of transport scale, and the enhancement of transport quality and efficiency. In total, economic development is the driving force for development of transport. There is one phenomenon: all the economic centers have a train station.

4.2.2 Airport express train

Flytoget, the Airport Express Train (Norwegian: Flytoget) is a Norwegian high-speed airport rail link connecting Oslo Airport, Gardermoen to Lillestrøm to Oslo Central Station in nineteen minutes. Every 10 min there an airport express train to the airport from Oslo S. Lillestrøm is the only stop station between Oslo S and Gardermoen Airport. It only takes 10 min from Lillestrøm to Oslo S and Gardermoen Airport.

4.3 Commuter flow into and out of Lillestrøm

Parliament decides to add the new main airport at Gardermoen on the Eighth of October, 1992 which gave new opportunities of growth and development for Lillestrøm. Later it was decided that the new airport train would be stopping in Lillestrøm. From being a village in the shadow of Oslo, Lillestrøm was transformed into a public transport junction on the road between the capital and Norway's new airport. Lillestrøm lies in the Skedsmo municipality which consists of two main cities, Lillestrøm and Kjeller.

From SSB, it is clear to see a significantly larger pool of commuters travel to Skedsmo for work, compared to the outbound commuter pool. That is, 64.3% of the employment in Skedsmo and 62.8% of the residents in Skedsmo. Commuter transport plays an important role for the commuter flow, of which railway is the main choice.

	0231 Skedsmo								
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
Employment by place of residence in the region	21408	21600	21424	21333	21560	22248	23290	24614	25028
Employees who commute into the region	13600	13569	14300	14193	14635	15510	16069	16824	16718
Employees who commute out of the region	13530	13526	13519	13392	13446	13863	14617	15446	15721
Employment by place of work in the region	21478	21643	22205	22134	22749	23895	24742	25992	26025

Table 4.3.1 Commuter situation of Skedsmo

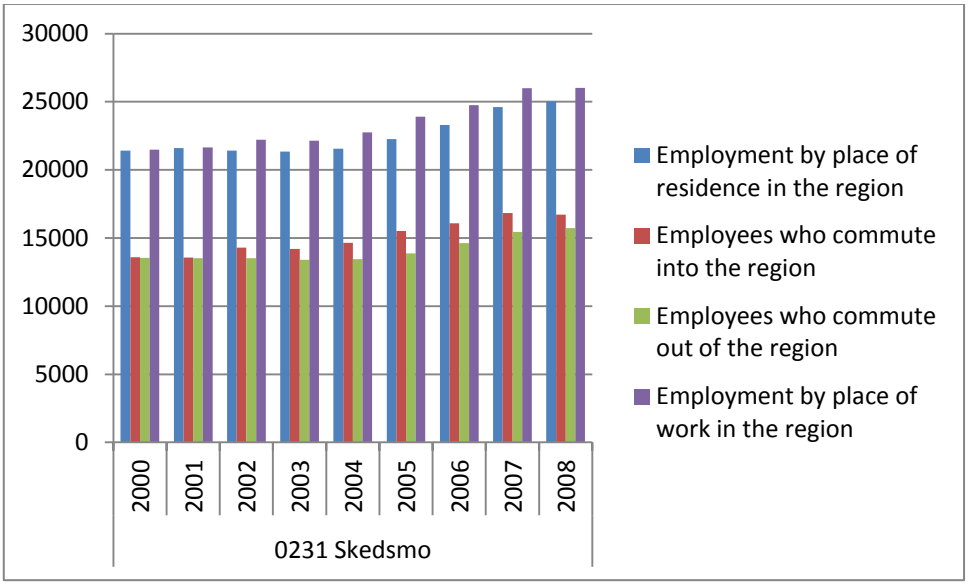


Figure 4.3.1 Commuter situation of Skedsmo

	0231 Skedsmo								
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
Employees who commute out of the region over residents	63.20%	62.62%	63.10%	62.78%	62.37%	62.31%	62.76%	62.75%	62.81%
Employees who commute into the region over employment	63.32%	62.69%	64.40%	64.12%	64.33%	64.91%	64.95%	64.73%	64.24%

Table 4.3.2 Commuter percentage

The above table displays the commuters as the percentage of residents and employment. The below figure shows labor market integration, which is the sum of commuters as a share of jobs and commuters out as a percentage of employees. Labor market integration can also be interpreted as commuting options. Arbeidsmakedsintegrasjon is a term that Telemark Research has introduced and which has great strategic importance for regional development. Skedsmo is one of the municipalities in the country's highest labor market integration, and the other major municipalities in Akershus, but these also have high labor market integration on a national scale.

Arbeidsmakedet in Skedsmo becomes progressively more integrated, while Ullensaker is the trending in the reverse direction.

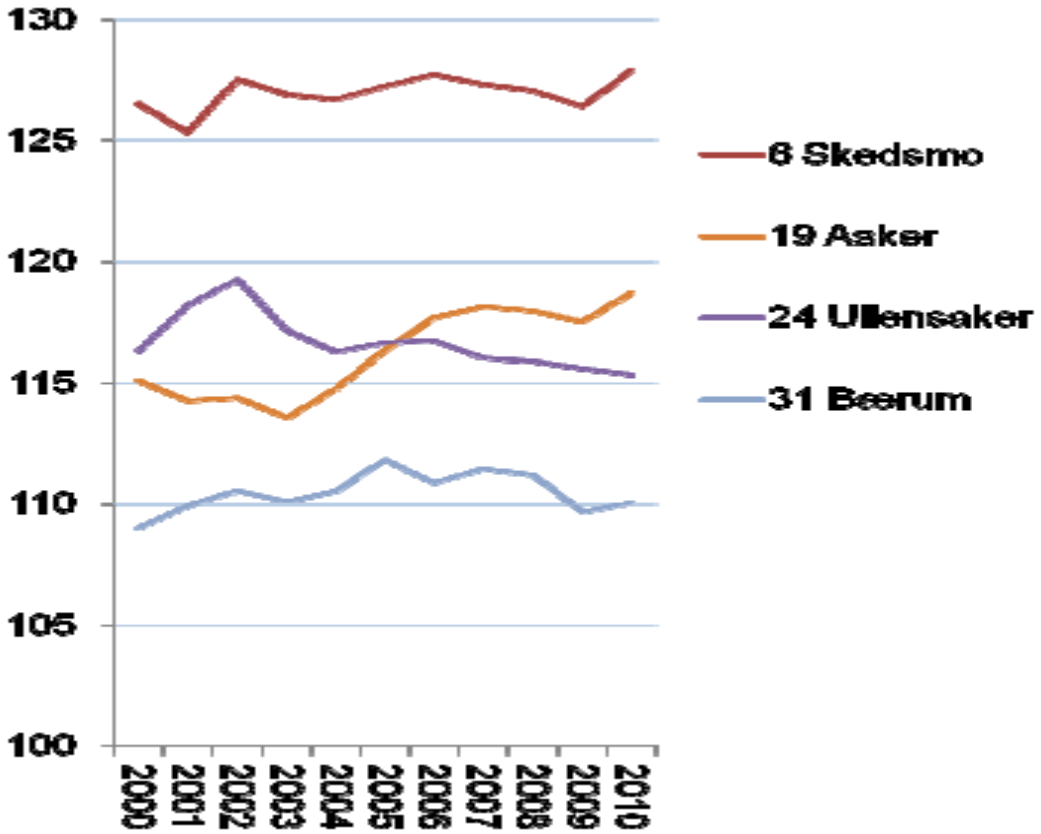


Figure 4.3.2 Labor market integration (Arbeidsmakedsintegrasjon)

4.4 GDP analysis of Lillestrøm by «Before-After» method

SSB was contacted with a request for GDP on a municipality level. However, the data was unavailable. Anders Taxt, a senior consultant, was able to provide relevant data on the Skedsmo municipality. Municipalities' studies use total expenses as a proxy for GDP. Mr. Taxt provided data from 1990 to 2011 for analysis.

Year	1990	1991	1992	1993	1994	1995	1996	
BNP	667570000	723739000	765603000	796507000	831806000	842748000	878845000	
Year	1997	1998	1999	2000	2001	2002	2003	
BNP	947935000	1.019E+09	1.082E+09	1.152E+09	1.287E+09	1.377E+09	1.512E+09	
Year	2004	2005	2006	2007	2008	2009	2010	2011
BNP	1.58E+09	1.723E+09	1.926E+09	2.059E+09	2.274E+09	2.456E+09	2.608E+09	2.84E+09

Table 4.4.1 Skedsmo total expenses from 1990 to 2011

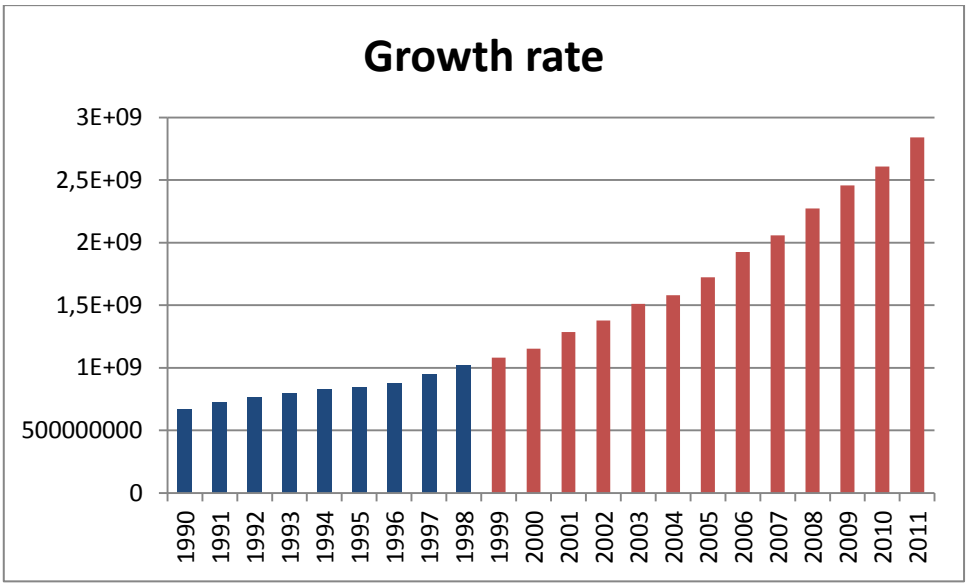


Figure 4.4.1 Total expenses of Skedsmo

1998 is the year of Gardermoenbanen opened. From 1990 to 1998, is marks blue column, while from 1999 to 2011, it marks red column.

($BNP_{Norwegian}$ = $GDP_{English}$)

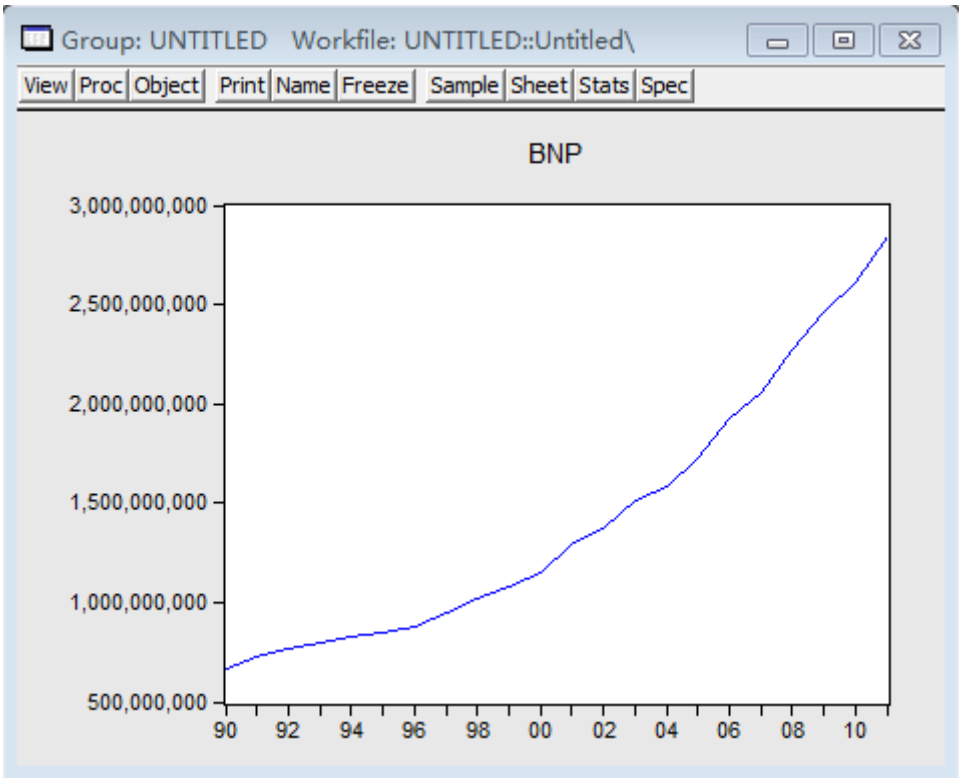


Figure 4.4.2 Total expenses in NOK of Skedsmo

As seen in Figure 4.4.2, Skedsmo's total expenses not only increased from 1990 to 2010, but that expenses appear to have increased at different rates roughly during the 1990's and the 2000's.

To get a clearer understanding of the trend, the nearest neighbor fit analysis of the scatter plot is used. The fit shows the slope changes with the total expenses value. This a good tool to judge the breakpoint.

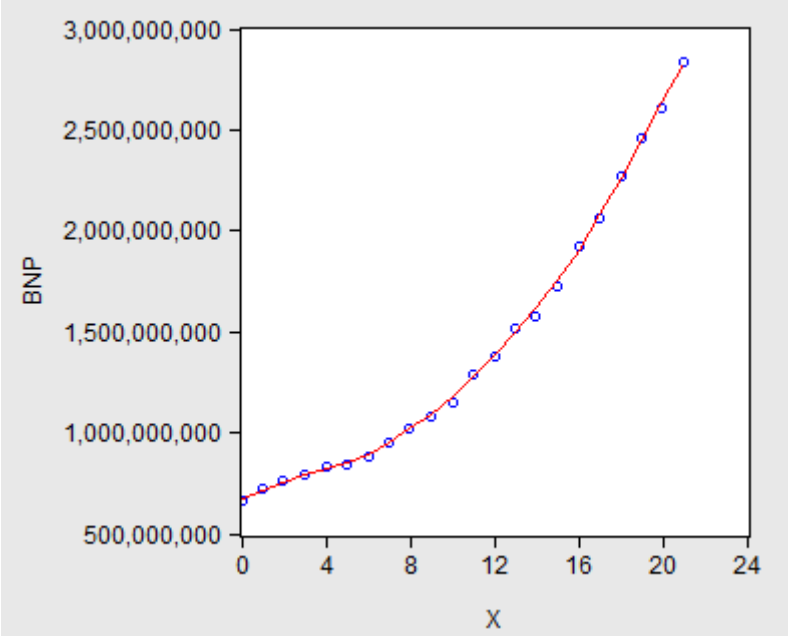


Figure 4.4.3 scatter graph

Testing the neighbor points for years 1996, 1997, 1998, 1999, 2000 and 2001 showed 1998—point 8 on the x-axis in Figure 4.4.3—to be the likely breakpoint. This aligns with the assumption of the effect the opening of Gardermoenbanen in 1998. As a result, the year 1998 has the most likelihood to be the breakpoint in the Chow breakpoint test.

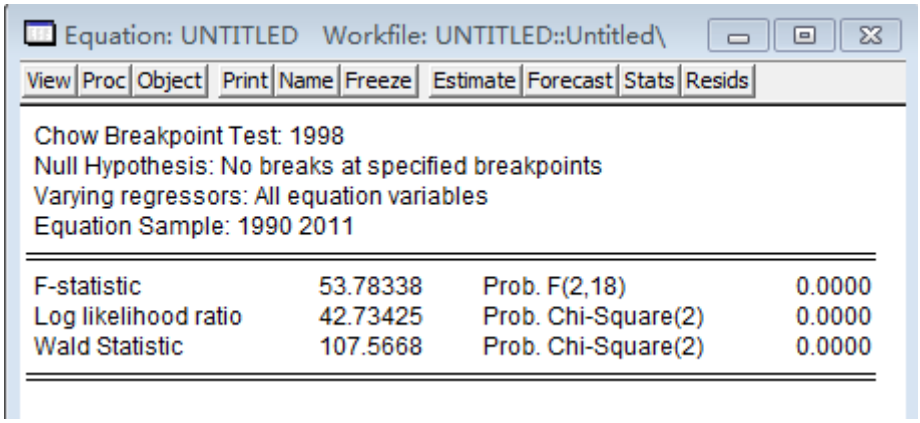


Figure 4.4.4 Chow breakpoint test

The series 1990 to 2011 is divided into two series: 1990 to 1998 and 1999 to 2011. By doing the regression of the two series, it conducts the equations.

The first period (1990 to 1998) least square regression

Equation: UNTITLED Workfile: HAHA::Untitled\

View | Proc | Object | Print | Name | Freeze | Estimate | Forecast | Stats | Resids

Dependent Variable: BNP_1
Method: Least Squares
Date: 07/06/12 Time: 11:02
Sample: 1990 1998
Included observations: 9

Variable	Coefficient	Std. Error	t-Statistic	Prob.
X_1	39200000	2698834.	14.52479	0.0000
C	6.74E+08	12849019	52.45364	0.0000

R-squared	0.967885	Mean dependent var	8.31E+08
Adjusted R-squared	0.963298	S.D. dependent var	1.09E+08
S.E. of regression	20905076	Akaike info criterion	36.74201
Sum squared resid	3.06E+15	Schwarz criterion	36.78584
Log likelihood	-163.3391	Hannan-Quinn criter.	36.64743
F-statistic	210.9696	Durbin-Watson stat	1.027839
Prob(F-statistic)	0.000002		

Figure 4.4.5 result of regression series 1

The level of significance over 99.99%

The equation is

BNP_1 = 39200000*X_1 + 673977777.778, with a the slope of 39200000

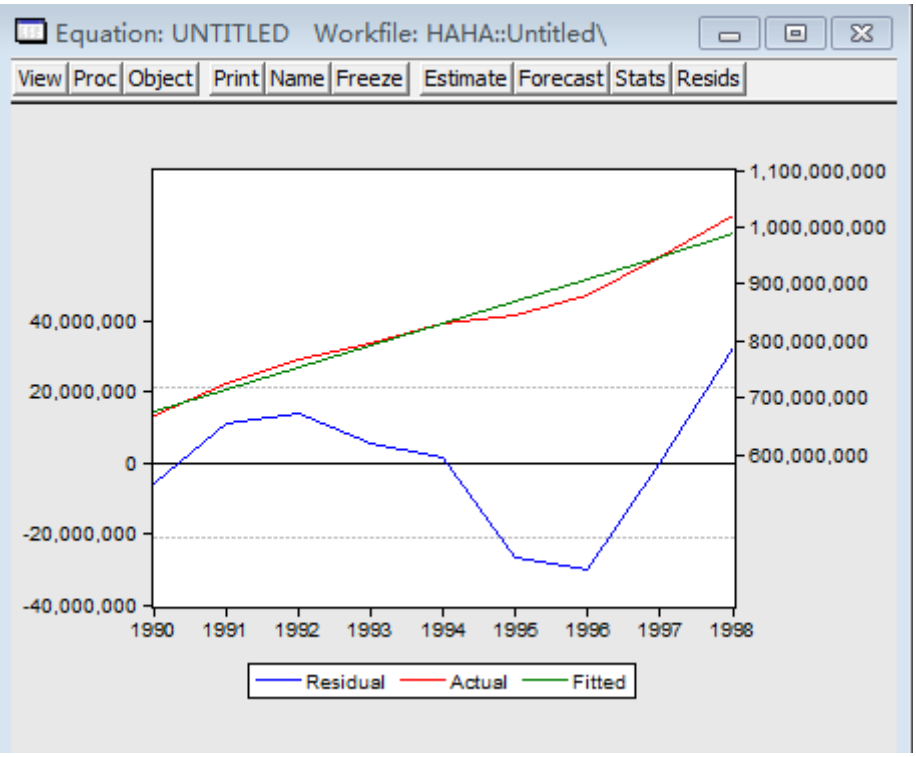


Figure 4.4.6 Residue graph

The second period (1999 to 2011) least square regression

Equation: UNTITLED Workfile: HENGHENG::Untitled\

View | Proc | Object | Print | Name | Freeze | Estimate | Forecast | Stats | Resids

Dependent Variable: BNP_2
Method: Least Squares
Date: 07/06/12 Time: 11:18
Sample: 1999 2011
Included observations: 13

Variable	Coefficient	Std. Error	t-Statistic	Prob.
X_2	1.46E+08	5998100.	24.42165	0.0000
C	9.58E+08	42412975	22.58795	0.0000

R-squared	0.981891	Mean dependent var	1.84E+09
Adjusted R-squared	0.980244	S.D. dependent var	5.76E+08
S.E. of regression	80918800	Akaike info criterion	39.39643
Sum squared resid	7.20E+16	Schwarz criterion	39.48334
Log likelihood	-254.0768	Hannan-Quinn criter.	39.37856
F-statistic	596.4170	Durbin-Watson stat	0.450766
Prob(F-statistic)	0.000000		

Figure 4.4.7 result of regression series 2

The significant possibility is over 99.99%

The equation is

BNP_2 = 146483516.484*X_2 + 958021978.022, with a slope of 146483516.484.

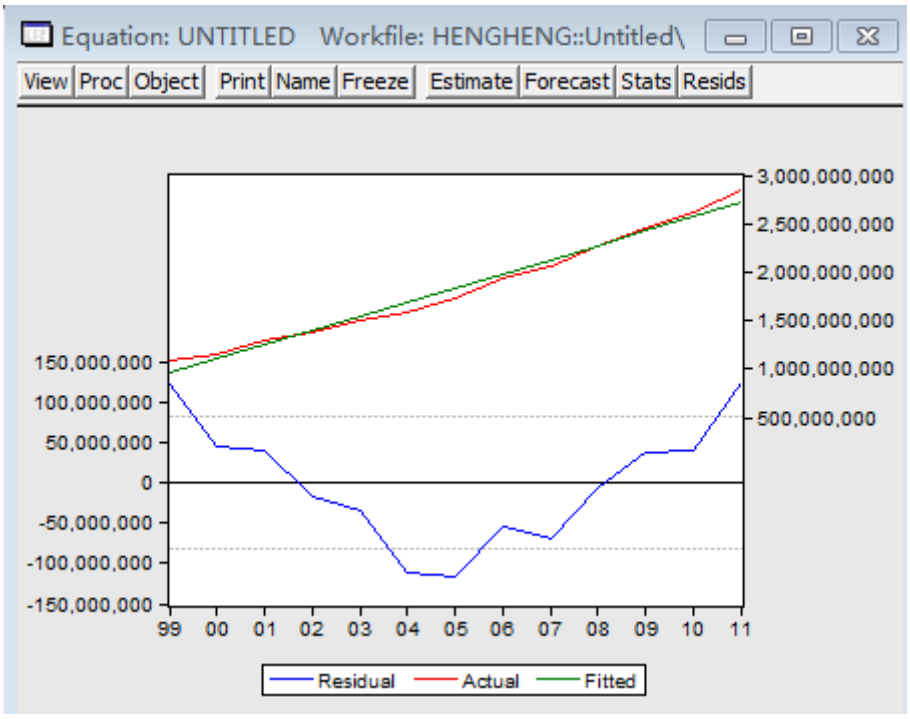


Figure 4.4.8 Residue graph

Conclusion: The slope in the second period (146483516.484) is higher than the first period (39200000).

obs	BNP
1990	NA
1991	8.41%
1992	5.78%
1993	4.04%
1994	4.43%
1995	1.32%
1996	4.28%
1997	7.86%
1998	7.53%
1999	6.19%
2000	6.43%
2001	11.71%
2002	7.00%
2003	9.81%
2004	4.49%
2005	9.07%
2006	11.80%
2007	6.87%
2008	10.43%
2009	8.03%
2010	6.16%
2011	8.92%

Table 4.4.2 Yearly growth rate

From the table 4.4.2, the average yearly growth rates are 5.45% for series 1 (1990---1998) and 8.22% for series 2 (1999---2011).

To sum up, the series from 1990 to 2011 has a breakpoint year in 1998, which divided the series in two—1990 to 1998 and 1999 to 2011. Linear regressions of both series resulted in equations with significant possibilities over 99.99%, indicating there are two slopes in the series 1990 to 2011. Both series 1 and 2 are continuous linear. Average yearly growth rates are calculated to be 5.45% for series 1 and 8.22% for series 2. This confirms average the economic growth rate has been higher after opening Gardermoenbanen.

4.5 New firms and number of employees with higher education

The number of new companies and employees with higher education increase continuously, even during the financial crisis period (2009). Lillestrøm came up with the objective to set up «Knowledge city», to attract more high technology companies and talent.

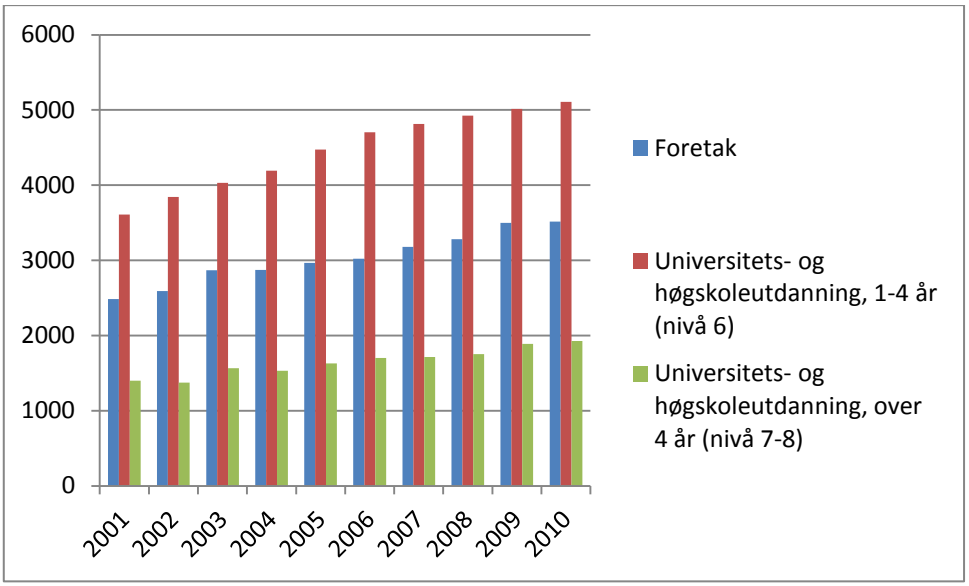


Figure 4.5.1 Number of companies (Foretak), employees with bachelor (1-4 years) and master (Over 4 years) degrees

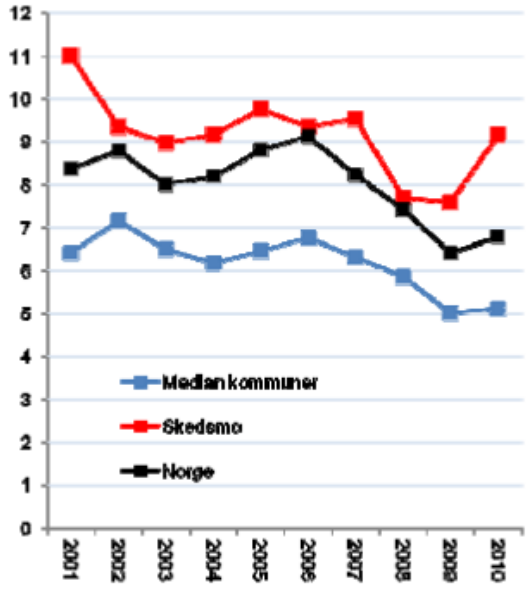


Figure 4.5.2 Yearly growing companies in Skedsmo and Norway between 2001 and 2010

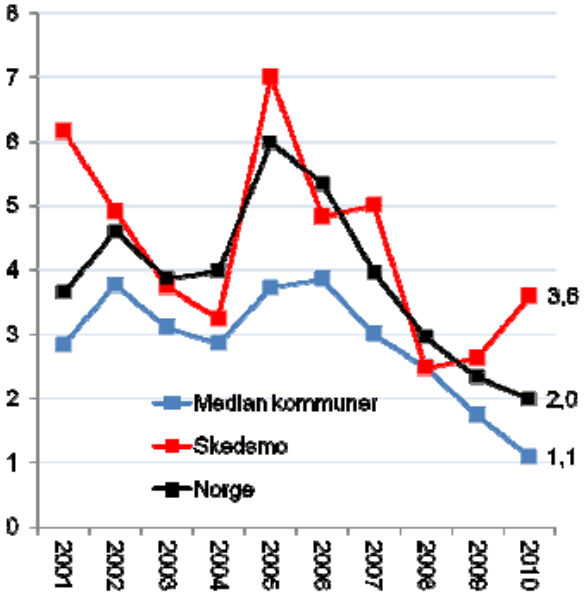


Figure 4.5.3 Establishment frequency in Skedsmo and Norway between 2001 and 2010

The figure on the left is the annual growth of the number of companies, while the figure on the right is the etablating frequency . From the two figures, it is clear to see the Skedsmo developed faster than the average rate of Norway and middle municipality (Median kommuner).

4.6 Quality of new established companies

The companies' survival time is a key factor to evaluate the new companies. The quality of new companies in Lillestrøm will be compared with Akershus County. Appendix C lists the data of Lillestrøm and Akershus County.

In order to measure the quality of new companies, the following two rules are made:

1. The percentage of companies which survived 5 years versus 1 year.

2. The employee expansion rate in 5 years for companies surviving 5 years.

Lillestrøm:

	2001	2002	2003
Survival percentage	51.2%	55.2%	56.5%
Expand rate	3.11	3.27	5.21

The Akershus County:

	2001	2002	2003
Survival percentage	54.2%	55.5%	56.1%
Expand rate	2.82	3.87	3.79

The survival percentage of Lillestrøm from 2001 to 2003 changes from 51.2% to 56.5%. The increased rate is much higher than Akershus, which is from 54.2% to 56.1%. The employee expansion rate goes up from 3.11 to 5.21, holding to an increasing trend. Akershus County fluctuates; the expansion rate moves from 2.82 to 3.87, then drops to 3.79. In the year 2003, the expansion rate was 5.21 in Lillestrøm; higher than the rate in Akershus.

In total, the quality of new companies in Lillestrøm is better than that in Akershus.

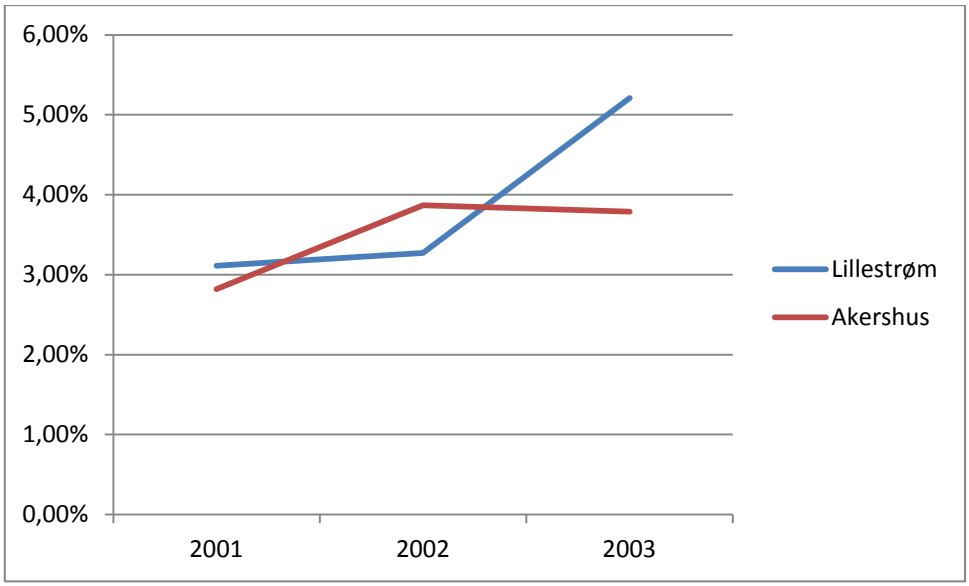


Figure 4.6.1 Survival rate comparison

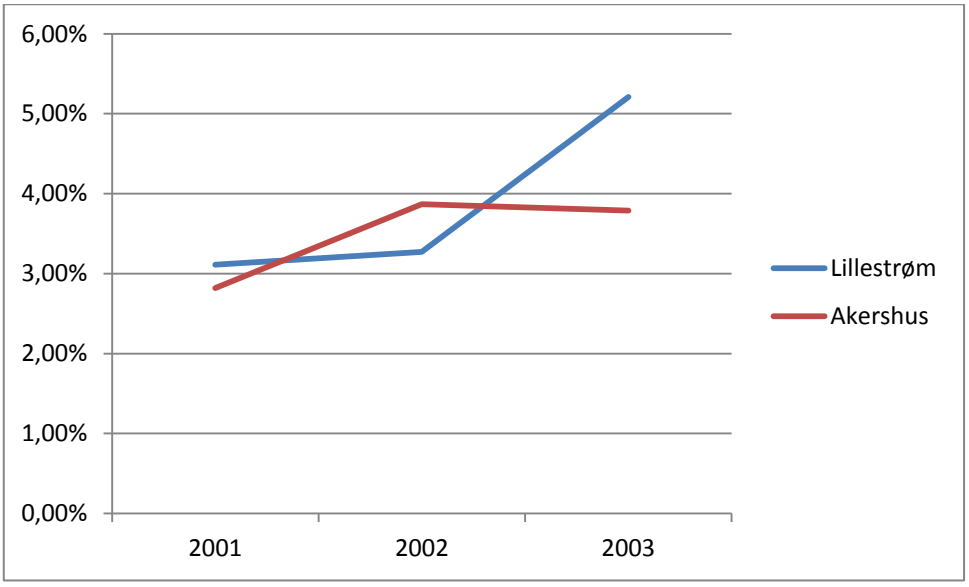


Figure 4.6.2 Expand rate comparison

4.7 Summary

Steam Technology and rail connection between Christiania and Eidsvold in 1854 made it possible to exploit Nitelva with access to timber for construction of extensive hands saw business. Lillestrøm industrialized as a place of sawmill operation from the middle of the 1850s. Over the next hundred years Lillestrøm changed and became characterized by the activity that gave the name Tile Town. Throughout the 1960s, the sawmill operation closed down because production was too expensive. The town has evolved to become a bedroom community of Oslo and elsewhere in the region. On the 8th of October 1992, the Parliament approved that Norway's

new international airport should be located near Gardermoen and later decided the Airport Express would make stops in Lillestrøm. These two key decisions gave Lillestrøm a central location, and the city could grow out of the shadows of Oslo.

Lillestrøm and Kjeller share few relations with each other historically. Lillestrøm was an industrial town and later as a more or less plain vanilla town. Kjeller has evolved independently of Lillestrøm with defense industry research and technology development. Throughout the 1990's both cities and knowledge communities started to take interest in each other, so that the two places that historically developed in relative isolation from each other now began to approach each other through knowledge.

In 1998, Gardermoenbanen was opened, Lillestrøm seized the opptunity to come up with a new strategy "Knowledge Lillestrøm". The total expenses of Lillestrøm increased quickly during the decade after Gardermoenbanen than period before. A good entrenprenurial environment has attracted more companies and talent. The number of new companies and employees with higher educations locating in the region has increased. Additionly, the quality of company is better than the average level of Akershus county over a 5 years period. About 63% employees commute in and out of Lillestrøm every weekday. Rail plays an important role in facilitating growth of the economy in Lillestrøm. It is obvious that Lillestrøm develops its economy and entreprenurial environment, in part, to the follow-up ripple effects of Gardmoenbanen.

5. POSTSCRIPT, LIMITATION AND FUTURE RESEARCH

This thesis researches on the follow-up ripple effects of Gardermoenbanen on the economy of Lillestrøm. The Gardermoenbanen improves the commuter facility, and creates good entreprenurial environment. The economy growes faster after the new railway line. More companies were established and more talent was attracted to Lillestrøm. The quality of newly established companis is better than the average level of Akershus county. Employees commuting in and out of Lillestrøm every weekday is 63%, and the new railway line plays an important role.

The Gardernmoenbanen connects Oslo Center, Lillestrøm, and Gardermoen Airport. This thesis only analyzes the economy of Lillestrøm, but omits the Oslo Center and Gardermoen Airport. In the future, I would like to collect the relative data of Oslo Center and Gardermoen Airport to research the follow-up ripple effects of Gardermoenbanen on the two places. Finally, the whole analysis of follow-up ripple effects of Gardermoenbanen would be accomplished.

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APPDENDIX A

Active Railway line in Norway (From Wikipedia)

Navn	Åpnet	Fylke(r)	Endestasjoner		Lengde
Hovedbanen	1854	Oslo og Akershus	Oslo S	Eidsvoll	84 km
Hamar–Grundsetbanen	1862	Hedmark	Hamar	Grundset	38 km
Kongsvingerbanen	1862	Akershus og Hedmark	Lillestrøm	Kongsvinger	115 km
Trondhjem–Størenbanen	1864	Sør-Trøndelag	Trondheim	Støren	51 km
Grensebanen	1865	Hedmark	Kongsvinger	Charlottenberg	-
Randsfjordbanen	1866/1868	Buskerud og Oppland	Drammen	Randsfjord	54 km
Drammenbanen	1872	Oslo, Akershus og Buskerud	Oslo S	Drammen	42 km
Spikkestadlinjen	1872	Akershus og Buskerud	Asker	Spikkestad	14 km
Skøyen–Filipstadlinjen	1872	Oslo	Skøyen	Filipstad	2 km
Rørosbanen	1877	Hedmark og Sør-Trøndelag	Hamar	Støren	382 km
Jærbanen	1878	Rogaland	Stavanger	Egersund	75 km
Østfoldbanen (Vestre)	1879	Oslo, Akershus og Østfold	Oslo S	Kornsjø	170 km
Hedemarksbanen	1880	Akershus og Hedmark	Eidsvoll	Hamar	-
Vestfoldbanen	1881/1882	Buskerud og Vestfold	Drammen	Skien	148 km
Meråkerbanen	1881	Sør-Trøndelag og Nord-Trøndelag	Trondheim S	Storlien	102 km
Østfoldbanen (Østre)	1882	Akershus og Østfold	Ski	Sarpsborg	80 km
Brevikbanen	1895	Telemark	Eidanger	Brevik	10 km
Gjøvikbanen	1900/1902	Oslo, Akershus og Oppland	Oslo S	Gjøvik	124 km
Alnabanen	1901	Oslo	Grefsen	Alnabru	5 km
Loenga–Alnabrulinjen	1901	Oslo	Loenga	Alnabru	7,3 km
Ofotbanen	1902	Nordland	Narvik	Bjørnfjell	43 km
Hell–Sunnanbanen	1905	Nord-Trøndelag	Hell	Sunnan	105 km
Arendalsbanen	1908	Aust-Agder	Nelaug	Arendal	37 km

Navn	Åpnet	Fylke(r)	Endestasjoner		Lengde
Treungenbanen	1908/1913	Aust-Agder og Telemark	Arendal	Treungen	92 km
Roa–Hønefosslinjen	1909	Oppland og Buskerud	Roa	Hønefoss	34 km
Bergensbanen	1909	Hordaland, Sogn og Fjordane og Buskerud	Bergen	Hønefoss	527 km
Kirkenes-Bjørnevatnbanen	1910	Finnmark	Kirkenes	Bjørnevatn	8,45 km
Solørbanen	1910	Hedmark	Kongsvinger	Elverum	88 km
Bratsbergbanen	1917	Telemark	Notodden	Eidanger	74 km
Dovrebanen	1921	Oslo, Akershus, Hedmark, Oppland og Sør-Trøndelag	Oslo S	Trondheim S	533 km
Raumabanen	1924	Oppland og Møre og Romsdal	Dombås	Åndalsnes	114 km
Flåmsbana	1940	Sogn og Fjordane	Myrdal	Flåm	20 km
Dalane–Suldallinjen	1944	Vest-Agder	Dalane	Suldal	1,1 km
Sørlandsbanen	1944	Buskerud, Telemark, Aust-Agder, Vest-Agder og Rogaland	Hokksund	Stavanger	528 km
Stavnebanen	1957	Sør-Trøndelag	Marienborg	Leangen	5,8 km
Nordlandsbanen	1962	Sør-Trøndelag, Nord-Trøndelag og Nordland	Trondheim S	Bodø	729 km
Gardermobanen	1998	Oslo og Akershus	Oslo S	Eidsvoll	64 km
Askerbanen	Sandvika-Asker 2005. Fullført Lysaker-Sandvika 2011.	Oslo og Akershus	Lysaker	Asker	9,7 km

APPDENDIX B

Commuter train in Big-Oslo area

300 Skøyen - Oslo S - Hakadal - Jaren - Gjøvik (Denne spesifikke strekningen driftes av NSB Gjøvikbanen, et datterselskap til NSB)

400 (Drammen) - Asker - Oslo - Lillestrøm (fast takt mellom Asker og Lillestrøm)

440 Drammen - Asker - Oslo - Jessheim - Dal (fast takt)

450 Eidsvoll - Oslo - Drammen - Kongsberg (fast takt)

460 Skøyen - Årnes - Kongsvinger (fast takt mellom Skøyen og Årnes)

500 Skøyen - Oslo - Ski (fast takt)

550 Spikkestad - Oslo - Moss (fast takt)

560 Skøyen - Oslo - Mysen - Rakkestad (fast takt mellom Skøyen og Mysen)

APPDENDIX C

Survival companies by year in Lillestrøm, the whole country and Akershus County.

Lillestrøm

	2001			2002		
	Companies	**Employees**	**Employees in the survival year**	**Companies**	**Employees**	**Employees in the survival year**
0293 Lillestrøm						
1 year						
Total	740	560	1,098	803	683	1,451
Growing in employment	321	170	783	308	238	1,064
Not Growing in employment	419	390	315	495	445	387
2 year						
Total	634	479	1,065	723	611	1,461
Growing in employment	308	120	798	301	240	1,163
Not Growing in employment	326	359	267	422	371	298
3 year						
Total	516	376	912	578	527	1,273
Growing in employment	260	114	714	240	208	1,042
Not Growing in employment	256	262	198	338	319	231

4 year						
Total	433	306	845	509	485	1,469
Growing in employment	217	109	706	224	204	1,269
Not Growing in employment	216	197	139	285	281	200
5 year						
Total	379	272	846	443	449	1,471
Growing in employment	198	99	716	211	201	1,298
Not Growing in employment	181	173	130	232	248	173

2003			2004			2005		
Companies	Employees	Employees in the survival year	Companies	Employees	Employees in the survival year	Companies	Employees	Employees in the survival year
767	598	1,764	829	501	1,395	787	454	1,165
278	146	1,384	389	203	1,146	350	179	934
489	452	380	440	298	249	437	275	231
705	515	1,954	721	424	1,426	723	404	1,385

319	166	1,711	366	202	1,251	359	185	1,203
386	349	243	355	222	175	364	219	182
568	434	1,846	622	390	1,585	634	366	1,383
265	141	1,638	346	197	1,438	323	177	1,235
303	293	208	276	193	147	311	189	148
484	398	1,811	547	342	1,452	0	0	0
240	139	1,630	307	132	1,294	0	0	0
244	259	181	240	210	158	0	0	0
434	360	1,876	0	0	0	0	0	0
219	145	1,736	0	0	0	0	0	0
215	215	140	0	0	0	0	0	0

2006	2007

Companies	Employees	Employees in the survival year	Companies	Employees	Employees in the survival year
941	499	1,282	983	576	1,506
396	216	1,039	382	240	1,223
545	283	243	601	336	283
873	423	1,475	0	0	0
391	181	1,281	0	0	0
482	242	194	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0

0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0

Akershus:

	2001			2002		
	Companies	Employees	Employees in the survival year	Companies	Employees	Employees in the survival year
02 Akershus						
1 year						
Total	2 293	3 372	5 181	2 591	3 825	10 709
Growing in employment	1 014	811	3 257	1 054	2 420	9 504
Not Growing in employment	1 279	2 561	1 924	1 537	1 405	1 205
2 year						
Total	1 968	1 724	4 052	2 318	3 548	10 788

Growing in employment	940	712	3 294	995	1 007	8 637
Not Growing in employment	1 028	1 012	758	1 323	2 541	2 151
3 year						
Total	1 652	1 493	3 496	1 920	3 313	10 541
Growing in employment	787	685	2 896	807	909	8 654
Not Growing in employment	865	808	600	1 113	2 404	1 887
4 year						
Total	1 423	1 252	3 250	1 638	3 151	11 036
Growing in employment	673	635	2 839	756	924	9 387
Not Growing in employment	750	617	411	882	2 227	1 649
5 year						
Total	1 243	1 134	3 193	1 438	2 847	11 040
Growing in employment	613	367	2 612	690	1 293	9 774
Not Growing in employment	630	767	581	748	1 554	1 266

2003	2004	2005

Companies	Employees	Employees in the survival year	Companies	Employees	Employees in the survival year	Companies	Employees	Employees in the survival year
2 413	2 055	4 494	2 766	1 859	7 305	2 544	1 448	3 829
897	619	3 261	1 236	917	6 551	1 084	619	3 123
1 516	1 436	1 233	1 530	942	754	1 460	829	706
2 151	1 729	4 794	2 384	1 625	7 527	2 313	1 247	4 408
947	645	3 975	1 169	851	6 943	1 136	592	3 868
1 204	1 084	819	1 215	774	584	1 177	655	540
1 774	1 514	4 746	2 021	1 457	7 874	2 056	1 138	4 494
826	574	4 019	1 129	780	7 357	1 046	561	4 030
948	940	727	892	677	517	1 010	577	464
1 523	1 386	4 857	1 782	1 300	7 710	0	0	0
754	536	4 187	1 001	696	7 245	0	0	0

769	850	670	781	604	465	0	0	0
1 354	1 270	4 818	0	0	0	0	0	0
682	672	4 386	0	0	0	0	0	0
672	598	432	0	0	0	0	0	0

2006			2007		
Companies	Employees	Employees in the survival year	Companies	Employees	Employees in the survival year
2 949	1 463	5 354	3 026	1 638	4 260
1 166	565	4 568	1 130	649	3 435
1 783	898	786	1 896	989	825
2 749	1 263	6 170	0	0	0
1 176	527	5 561	0	0	0
1 573	736	609	0	0	0

0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0